



**HAL**  
open science

## **The effect of school-based interventions on HPV vaccine-related knowledge, attitudes, and practices among adolescents in France: Secondary results from the PrevHPV trial**

Josée Dussault, Alexia Rivera Torres, Damien Oudin Doglioni, Amandine Gagneux-Brunon, Anne-Sophie Le Duc-Banaszuk, Sébastien Bruel, Morgane Michel, Aurélie Gauchet, Anne-Sophie Barret, Jonathan Sicsic, et al.

### **► To cite this version:**

Josée Dussault, Alexia Rivera Torres, Damien Oudin Doglioni, Amandine Gagneux-Brunon, Anne-Sophie Le Duc-Banaszuk, et al.. The effect of school-based interventions on HPV vaccine-related knowledge, attitudes, and practices among adolescents in France: Secondary results from the PrevHPV trial. *Vaccine*, 2025, 61, pp.127344. <10.1016/j.vaccine.2025.127344>. <hal-05104906>

**HAL Id: hal-05104906**

**<https://ehesp.hal.science/hal-05104906v1>**

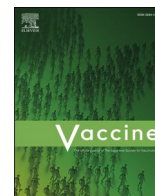
Submitted on 13 Jun 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY 4.0 - Attribution - International License



## The effect of school-based interventions on HPV vaccine-related knowledge, attitudes, and practices among adolescents in France: Secondary results from the PrevHPV trial

Josée M. Dussault<sup>a</sup>, Alexia F. Rivera Torres<sup>b</sup>, Damien Oudin Doglioni<sup>c</sup>,  
Amandine Gagneux-Brunon<sup>d,e,1</sup>, Anne-Sophie Le Duc-Banaszuk<sup>f,1</sup>, Sébastien Bruel<sup>g,h,1</sup>,  
Morgane Michel<sup>i,j</sup>, Aurélie Gauchet<sup>k</sup>, Anne-Sophie Barret<sup>l</sup>, Jonathan Sicsic<sup>m</sup>, Jocelyn Raude<sup>n</sup>,  
Nathalie Thilly<sup>o,p</sup>, Judith E. Mueller<sup>a,n,\*</sup>, On behalf of the PrevHPV Consortium

<sup>a</sup> Emerging Disease Epidemiology Unit, Institut Pasteur, Université Paris Cité, 25 rue du Dr Roux, 75015 Paris, France

<sup>b</sup> EHESP French School of Public Health, 93210 La Plaine Saint Denis, France

<sup>c</sup> Univ. Grenoble Alpes, Univ. Savoie Mont-Blanc, LIP/PC2S, 38000, Grenoble, France

<sup>d</sup> Centre International de Recherche en Infectiologie, Team GIMAP, Univ Lyon, Université Jean Monnet, Université Claude Bernard Lyon 1, Inserm, U1111, CNRS, UMR530, France

<sup>e</sup> CIC INSERM 1408 Vaccinologie, CHU de Saint-Etienne, France

<sup>f</sup> Centre Régional de Coordination des Dépistages des cancers-Pays de la Loire, Angers, France

<sup>g</sup> Department of General Practice, Jacques Lisfranc Faculty of Medicine, Saint-Etienne-Lyon University, Saint-Etienne, France

<sup>h</sup> CIC-Inserm, 1408 CHU de Saint-Etienne, France

<sup>i</sup> Université Paris Cité, ECEVE, UMR 1123, Inserm, F-75010 Paris, France

<sup>j</sup> Assistance Publique-Hôpitaux de Paris, Hôpital Robert Debré, Unité d'épidémiologie clinique, F-75019 Paris, France

<sup>k</sup> Univ. Savoie Mont Blanc, Univ. Grenoble Alpes, LIP/PC2S, 38000, Grenoble, France

<sup>l</sup> Santé publique France, 12 rue du Val d'Osne, 94415 Saint-Maurice, Cedex, France

<sup>m</sup> Université Paris Cité, Chaire AgingUP! and LIRAES (URP 4470), F-75006, Paris, France

<sup>n</sup> Université de Rennes, EHESP, CNRS, Inserm, Arènes - UMR 6051, RSMS (Recherche sur les Services et Management en Santé) - U 1309 -, F-35000 Rennes, France

<sup>o</sup> Université de Lorraine, Inserm, INSPIRE, F-54000 Nancy, France

<sup>p</sup> Université de Lorraine, CHRU-Nancy, Département Méthodologie, Promotion, Investigation, F-54000 Nancy, France

### ARTICLE INFO

#### Keywords:

HPV  
Vaccination  
Adolescents  
Knowledge  
Attitudes  
Practices

### ABSTRACT

**Background:** In France, HPV vaccine uptake among adolescents remains a public health concern. Therefore, we examined changes in French adolescents' knowledge, attitudes, and practices (KAP) following exposure to HPV-vaccination-related interventions.

**Methods:** Our cluster-randomized trial applied an incomplete factorial design to allocate three intervention components (in-school education, free in-school vaccination, and general practitioner [GP] trainings) into six arms, randomly assigned to 91 French municipalities. Adolescents' ( $N = 2758$ ; typically aged 13–14) self-reported HPV-vaccine-related KAP was assessed via online questionnaires at baseline and follow-up. Using logistic regression, we estimated the decomposed effects of each intervention component on favorable responses to individual KAP items. Each model adjusted for the baseline level of the outcome. We conducted subgroup analyses of the effect of the education component.

**Results:** Adolescents who received in-school education, compared to those who did not, provided improved responses on all knowledge items at follow-up. They also reported more favorable attitudes, which included the

**Abbreviations:** HPV, Human Papillomavirus; STI, Sexually Transmitted Infection; GP, General Practitioner; HCP, Healthcare Provider; US, United States; UK, United Kingdom.

\* Corresponding author at: Emerging Disease Epidemiology Unit, Institut Pasteur, 25-28 rue du Dr Rous, 75724, Paris cedex 15, France.

**E-mail addresses:** [josee.dussault@unc.edu](mailto:josee.dussault@unc.edu) (J.M. Dussault), [alexia.riveratorres@edu.ehesp.fr](mailto:alexia.riveratorres@edu.ehesp.fr) (A.F. Rivera Torres), [damien.oudin-doglioni@univ-grenoble-alpes.fr](mailto:damien.oudin-doglioni@univ-grenoble-alpes.fr) (D. Oudin Doglioni), [Amandine.Gagneux-Brunon@chu-st-etienne.fr](mailto:Amandine.Gagneux-Brunon@chu-st-etienne.fr) (A. Gagneux-Brunon), [as.banaszuk@depistagecancers.fr](mailto:as.banaszuk@depistagecancers.fr) (A.-S. Le Duc-Banaszuk), [morgane.michel@aphp.fr](mailto:morgane.michel@aphp.fr) (M. Michel), [aurelie.gauchet@univ-smb.fr](mailto:aurelie.gauchet@univ-smb.fr) (A. Gauchet), [Anne-Sophie.BARRET@santepubliquefrance.fr](mailto:Anne-Sophie.BARRET@santepubliquefrance.fr) (A.-S. Barret), [jonathan.sicsic@parisdescartes.fr](mailto:jonathan.sicsic@parisdescartes.fr) (J. Sicsic), [Jocelyn.Raude@ehesp.fr](mailto:Jocelyn.Raude@ehesp.fr) (J. Raude), [n.thilly@chru-nancy.fr](mailto:n.thilly@chru-nancy.fr) (N. Thilly), [Judith.MUELLER@ehesp.fr](mailto:Judith.MUELLER@ehesp.fr) (J.E. Mueller).

<sup>1</sup> Authors contributed equally

<https://doi.org/10.1016/j.vaccine.2025.127344>

Received 2 April 2025; Received in revised form 25 May 2025; Accepted 27 May 2025

Available online 5 June 2025

0264-410X/© 2025 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

perceived benefit-risk balance (OR = 1.6 [95 %-CI, 1.2–2.0]) and judging reduced onward transmission as important (1.5 [1.1–2.1]). In-school education increased the likelihood of having HPV-vaccine-related discussions with friends (1.8 [1.2–2.6]). In-school vaccination increased adolescents' likelihood of knowing that friends are vaccinated (3.1 [2.2–4.2]), and perceived accessibility (2.2 [1.5–3.2]). Perceived difficulties in accessing clear vaccine information increased specifically among multilingual adolescents (0.5 [0.2–0.9]).

**Conclusion:** Free in-school HPV vaccination significantly increases perceived ease of access to HPV vaccination for students who are already motivated to get vaccinated, and in-school education and motivation improves students' HPV vaccine-related knowledge and attitudes and can encourage them to get vaccinated. Thus, when offered together over the course of multiple academic years, we would expect to see increased vaccine uptake as adolescents become both more amenable toward vaccination and perceive easier access. Educational material needs tailoring for families from different linguistic and cultural backgrounds.

## 1. Background

The human papillomavirus (HPV) constitutes a significant global public health concern [1]. It is estimated that 80–90 % of sexually active individuals acquire HPV during their lifetime in the absence of an HPV vaccination program [2]. Persistent infections can develop into certain types of cancers, including cervical, anal and oropharyngeal cancers. It can also result in anogenital warts and respiratory papillomatosis, which significantly impact quality of life [1,3,4]. Since 2006, there have been safe HPV vaccines that effectively prevent infection with the high-risk HPV types that cause the majority of cancers and anogenital warts [1,5,6]. The World Health Organization (WHO) currently recommends HPV vaccination for all girls aged 9–13 years old; vaccination for boys and older women are secondary targets where affordable and feasible [1].

In France, HPV vaccination has been recommended for girls aged 14 years or older since 2007, and recommendations shifted in 2013 to target girls aged 11–14 with a two-dose schedule [7]. In 2019, the National Authority for Health (HAS) recommended HPV vaccination for boys of the same age; this recommendation was endorsed and subsequently included the immunization schedule for all adolescents 2020; it was reimbursable by public health insurance in 2021 [8,9]. Thus, in 2020, the overwhelming majority of vaccinated adolescents were girls, and first-dose vaccine coverage for girls by age 15 was 41 %; complete coverage was 37 % [10]. By 2023, first-dose vaccine coverage for girls and boys by age 15 was 55 % and 26 %, respectively [10]. Complete vaccination coverage also increased, with 45 % of girls and 16 % of boys completing their vaccine schedules by the age of 15 [10]. Despite this positive trend, these estimates are still below the vaccination targets outlined in both the National Sexual Health Strategy and the ten-year Cancer Control Plan, whose goal is 80 % coverage by 2030 [11,12].

In France, adolescents have shown limited understanding around HPV infection, cervical cancer, and HPV vaccination [13–15]. In previous studies, girls have reported that they had not received any information from their teachers or school nurses about the vaccine, although they did agree that these would be trustworthy sources of information [13,16]. They also expressed a desire to become more informed and involved in their health decision-making, while showing a strong interest in HPV and cervical cancer [13,15,16]. In France, consent from both parents is legally required for vaccination of minors. Nevertheless, one might expect that improving health communication and HPV education strategies targeting adolescents may enhance their understanding, increase awareness, and cultivate favorable attitudes toward HPV vaccination [17].

Adolescence is a crucial developmental period where individuals begin to form their own beliefs, attitudes, skills, and decision-making processes, particularly regarding their health behaviors [18]. The age at which the HPV vaccine is administered in France aligns with significant life and social changes, including school transitions as adolescents begin middle school. This developmental stage is noteworthy, as adolescents are seeking more maturity and independence from parents while experiencing closer social interactions with peers [13,19]. Thus, to increase HPV vaccine uptake among adolescents in France, it is

necessary to thoroughly understand how information and vaccine promotion campaigns can impact adolescents' HPV vaccine-related knowledge, attitudes, and practices (i.e., behaviors). Accordingly, we present a secondary analysis of data from an HPV vaccine intervention, where we assess whether the three intervention components (in-school education, in-school vaccine campaigns, and local GP training) influenced HPV vaccine-related knowledge, attitudes, and practices, which represent common psychological antecedents of vaccination, among adolescents at participating middle schools (aged 13–15 years) in France.

## 2. Methods

### 2.1. Study design

#### 2.1.1. Overview

The PrevHPV consortium was established to co-construct and evaluate a multicomponent intervention to increase HPV vaccination coverage among adolescents in France [20]. In the experimental phase of the PrevHPV project, 91 French municipalities were block randomized (block size = 6) using a computer-based random allocation led by a senior study member (NT). The primary trial outcome, whose results are reported elsewhere [21], was municipality-level HPV vaccine coverage. In the present manuscript, we report results on a pre-registered secondary outcome: adolescents' vaccine-related knowledge, attitudes, and practices (i.e., behaviors), assessed by self-administered online questionnaires at baseline and at a 5-month follow-up.

#### 2.1.2. Intervention components

There were three intervention components arranged into six intervention conditions using an incomplete factorial design: 1) in-school education and motivation offered to adolescents during class, including participatory learning and eHealth tools such as videos and video games; additional information sessions were offered to parents, but were poorly attended and reached a very small audience 2) free, in-school HPV vaccination offered to adolescents in *4ème* and *3ème* (equivalent to US grades 8 and 9 and UK years 9 and 10; students aged approx. 13–15 years), with consent required from the students' custodial guardians; and 3) training and support for general practitioners (GPs; Table 1). GP e-learning sessions were designed to reinforce GPs' knowledge of HPV infection and vaccination. These sessions also helped GPs strengthen their motivational interviewing skills to recommend the HPV vaccine to adolescents and their parents [20]. The six intervention conditions were randomly allocated to 91 municipalities across France; intervention activities occurred between September 2021 to April 2022, thus pre-dating the rollout of in-school vaccination in all French middle schools in the autumn of 2023. This was an open-label study, meaning that both the schools and the study team members responsible for administering the interventions were aware of the intervention assignments; middle school students and their parents were not explicitly informed about the experimental group assignment of their school.

**Table 1**  
Intervention components per randomization arm.

	In-school education and motivation <sup>1</sup>	General practitioner training <sup>2</sup>	Free in-school vaccination <sup>3</sup>
Arm 1 (n = 15 middle schools)	X	X	X
Arm 2 (n = 15 middle schools)	X	X	
Arm 3 (n = 15 middle schools)	X		X
Arm 4 (n = 15 middle schools)	x		
Arm 5 (n = 15 middle schools)		X	
Arm 6 (n = 15 middle schools)			

<sup>1</sup> The in-school education and motivation component included: 1) a web conference on HPV infection and vaccination for parents, and 2) two educational group sessions on HPV infection and vaccination for adolescents, delivered by their teachers during regular school hours using eHealth tools (videos, serious video game) and participatory learning.

<sup>2</sup> The general practitioner training component included individual e-learning sessions which offered updated information on HPV infection/vaccination, lessons on motivational interviewing techniques when offering vaccination, and presentation of a decision aid tool designed to help hesitant individuals decide whether to vaccinate.

<sup>3</sup> The free, in-school vaccination component consisted of a vaccination day organized at the middle school, with health professionals from local vaccination centers offering the HPV vaccine free of charge, without any medical prescription required, for eligible adolescents. Parents were informed of the vaccination day in advance, and adolescents could only be vaccinated with parental consent.

### 2.1.3. Eligibility criteria

The target population of this analysis were students attending middle schools in participating municipalities. To be considered for the intervention, municipalities were required to satisfy the following criteria: 1) they must have only one middle school in the municipality, and 2) at least two-thirds of adolescents within the 11-to-14-year age category must have been enrolled in this middle school. More details on inclusion and municipality selection can be found in the previously published trial protocol [20].

## 2.2. Data collection

Data from adolescents were self-reported via an anonymous questionnaire published on REDCap. Starting in November 2021, prior to the rollout of in-school intervention activities, adolescents in the grades 4<sup>ème</sup> and 3<sup>ème</sup> were allotted class time to complete the baseline questionnaire using a unique and anonymized identifier. To assess the effectiveness and implementation of the intervention, students were invited to complete a follow-up questionnaire through the same process, using the same IDs as the baseline questionnaire, approximately two months after the conclusion of intervention activities within each municipality. The present analysis only includes questionnaire data from the 2758 students whose IDs could be matched between the baseline and follow-up questionnaires (see Fig. 1 for full participant flowchart). On average, there was an approximate five-month period between these

two timepoints.

## 2.3. Outcome: Adolescent knowledge, attitudes, and practices (KAP)

KAP questions probed respondents about HPV vaccine coverage in other countries, the benefits versus risks of vaccination, the ease of access to the HPV vaccine, and whether they discussed HPV vaccination with family and friends, among other items (see Supplementary Table 1). No validated questionnaire with sufficient granularity was available prior to the study. We therefore developed the items following the “7C” framework of psychological antecedents of vaccination [22], with at least one knowledge, attitude and practice item per 7C domain to ensure that a large panel of concepts were covered in the questionnaire. Previous confirmatory factor analysis of the PrevHPV KAP data demonstrated that not all KAP items of our questionnaire contributed to the 7C domains and the related 7C score of vaccine readiness [23]. Therefore, in the present analysis, we assumed uniqueness of the KAP items and treated each follow-up KAP item as an individual outcome variable.

## 2.4. Statistical analysis

We analyzed the decomposed effects of the three intervention components on adolescents’ KAP items. In all models, the intervention components were designed as three disjoint indicator variables with the referent category as no intervention; this exposure modeling scheme allowed us to estimate the decomposed effects of each of the three intervention components rather than the effect per each of the six randomization conditions. To analyze the impact of the components on adolescents’ individual knowledge, attitudes, and practices, we categorized all relevant interview items into binary outcomes, distinguishing between favorable (i.e., desirable) and unfavorable responses. Neutral or indecisive response options were grouped with unfavorable responses. Using logistic regression, we modeled the relationship between the intervention components and adolescents’ follow-up responses to individual KAP items, while adjusting for participants’ baseline response to the respective items. To summarize results, the log odds ratios were output into forest plots to allow more accurate comparison between values on the log scale. In the text, we present the odds ratio values for ease of interpretation.

Informed by previous results of the PrevHPV study, suggesting that in-school education and motivation had a positive effect on self-reported vaccine uptake or intention to get vaccinated for French monolingual, but not multilingual students [24], we also explored the effects of the in-school education and motivation component within strata of in-home multilingualism. This variable was binary: students either exclusively spoke French at home or spoke another language (besides French) at home, too. These stratified estimates were also summarized in forest plots.

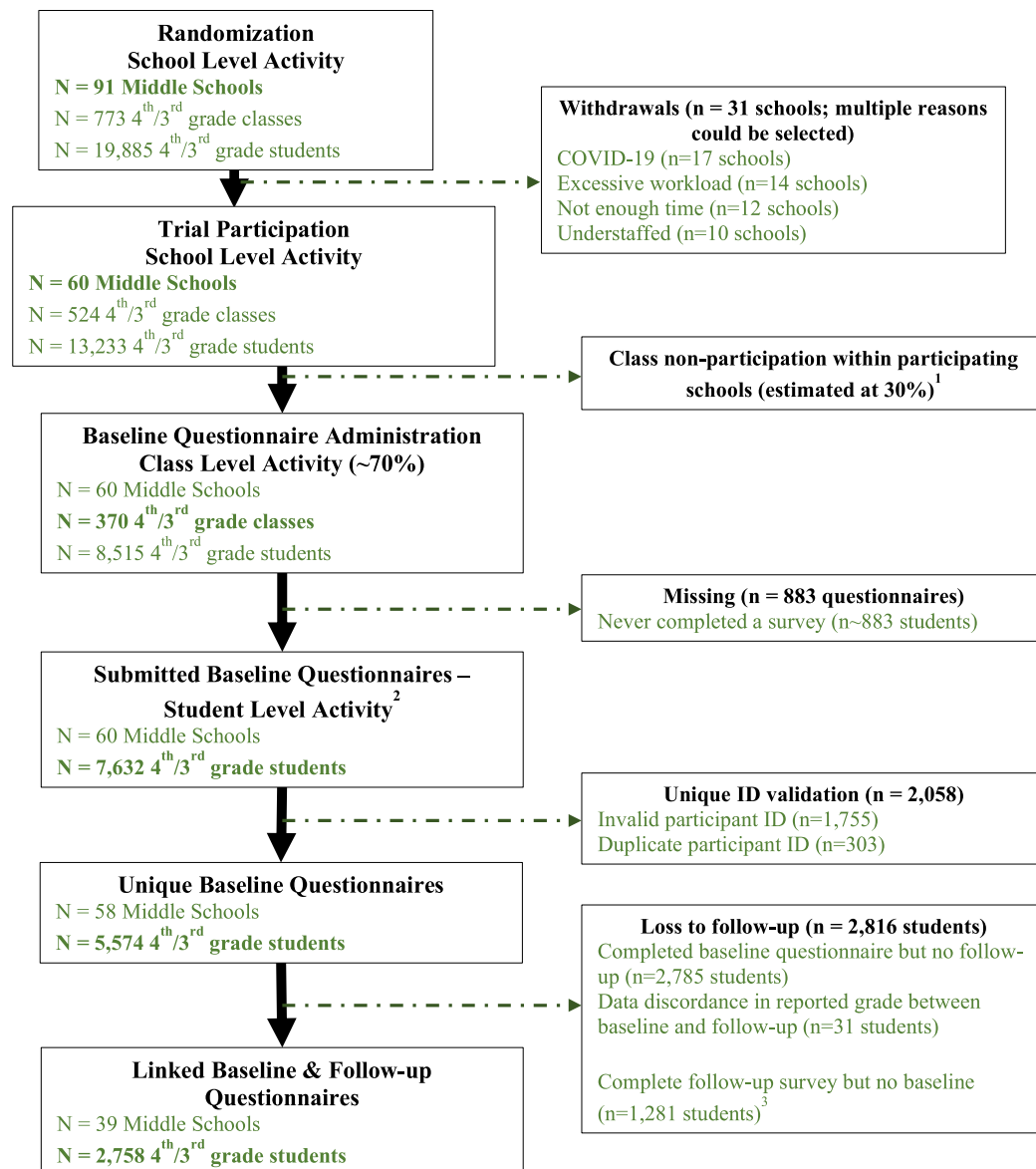
All regression models accounted for the clustering of participants within municipalities. All analyses were conducted in STATA 17 [25]. Forest plots were created in RStudio using the ggplot2 package [26].

## 3. Results

The final sample of adolescents included 2758 students from 39 schools after data cleaning and questionnaire linkage between baseline and follow-up (Fig. 1). Adolescents were distributed evenly by gender (53 % of girls) and school grade (54 % in 4<sup>ème</sup>, approximately age 13), with limited variation across randomization arms. In the overall sample, 560 (20 %) adolescents reported speaking another language (other than French) fluently at home, and this proportion varied widely by randomization arm (e.g., 10 % in Arm 1 and 33 % in Arm 5; Table 2). At baseline, 1587 (59 %) of participants said that they had heard of the HPV vaccine before, while 283 (10 %) were not sure, and 829 (31 %) were sure that they had not heard of the vaccine. By follow-up, 2349 (86

289  
290  
291  
292  
293  
294  
295  
296  
297  
298  
299  
300  
301  
302  
303  
304  
305  
306  
307  
308  
309  
310  
311  
312  
313  
314  
315  
316  
317  
318  
319  
320  
321  
322  
323  
324  
325  
326  
327  
328  
329

**Figure 1. Participant Flowchart**



<sup>1</sup> Estimates of 30% class non-participation were extrapolated based on the 'education and motivation' sample of classrooms.  
<sup>2</sup> IDs in questionnaires allowed unique identification of schools but not classrooms, therefore class participation in questionnaires cannot be directly calculated.  
<sup>3</sup> Not included in calculation of loss to follow up.

**Fig. 1.** Participant Flowchart.

%) were sure that they had heard of the HPV vaccine. The median time between an adolescent’s baseline (November 2021–March 2022) questionnaire response and their follow-up survey response (May 2022 – June 2022) was 4.5 months (IQR: 4.2–4.9).

Almost all KAP items showed a substantial increase of prevalence of vaccine-favorable responses between baseline and follow-up (Table 2). Of note, there was a 22 percentage-point increase in remembering education on sexually transmitted infections (STIs) at school in the overall respondent sample (68 % at baseline vs 90 % at follow-up; Table 2).

On average, the in-school education and motivation intervention

component had the largest effect on KAP items, compared to the other intervention components. In regression analyses adjusting for baseline levels of KAP items and receipt of other intervention components, participants who received this component, compared to participants who did not, had an increased odds of providing a favorable response on all knowledge items at follow-up (Fig. 2). For example, the odds of awareness of high vaccine coverage in the UK and Portugal was 7.2 (95 %-confidence interval [95 %-CI]: 4.8, 10.8) times higher among adolescents who received this component than those who did not. Similarly, students who received in-school education and motivation were more

**Table 2**

Description of the participant sample (N = 2758) and of prevalences of vaccine-favorable knowledge, attitudes and practice item responses at baseline and follow-up.

Variable Name	N (%)						
	Arm 1	Arm 2	Arm 3	Arm 4	Arm 5	Arm 6	Total
<b>Multilingualism:</b> Speaking also another language fluently at home (vs only French)	22 (10)	86 (24)	116 (17)	105 (21)	94 (33)	137 (19)	560 (20)
<b>Gender:</b> Girl (vs boy)	120 (55)	176 (49)	348 (51)	288 (56)	164 (58)	362 (51)	1458 (53)
<b>Grade:</b> 4 <sup>ème</sup> (vs 3 <sup>ème</sup> )	124 (56)	212 (59)	346 (51)	296 (58)	160 (57)	360 (51)	1498 (54)
<b>Non-missing responses to above items</b>	220	362	679	510	281	705	2757

Variable Name	Baseline		Follow-up	
	Vaccine-favorable responses (n [%]) <sup>1</sup>	Missing <sup>2</sup>	Vaccine-favorable responses (n [%]) <sup>1</sup>	Missing <sup>2</sup>
Heard of the HPV vaccine before	1587 (59)	59	2349 (86)	42
Doctor talked to me about HPV	799 (30)	103	955 (36)	85
Doctor offered HPV vaccine to me	739 (28)	123	923 (35)	103
Talked with parents about HPV vaccination	852 (31)	23	1105 (40)	19
Education on STIs at school	1832 (68)	78	2428 (90)	59
Gender-neutral HPV vaccination recommendation	1315 (52)	865	2098 (83)	237
Ideal age range for HPV vaccination	1185 (47)	865	1728 (69)	236
Vaccine coverage for 15-year-olds in UK & other countries	114 (5)	866	521 (21)	236
How long the HPV vaccine has been monitored for safety	318 (13)	866	577 (23)	237
Cancer elimination via HPV vaccination	570 (23)	866	958 (38)	238
I have enough knowledge about the vaccine	287 (11)	866	797 (32)	238
Better immune response to HPV vaccine before age 14	1123 (45)	865	1726 (69)	238
Most people around me are favorable to HPV vaccination	1009 (42)	986	1237 (51)	352
My friends are vaccinated against HPV	934 (37)	888	1458 (58)	254
Easy to find clear info about HPV vaccine	868 (36)	931	1393 (57)	314
I think the HPV vaccine is safe	1147 (46)	871	1637 (65)	247
Personally, HPV vaccination is easy to access	1152 (46)	872	1565 (62)	250
Personally, HPV vaccination is useful	1397 (56)	872	1836 (73)	247
Not transmitting HPV to others is important	1518 (61)	875	1976 (79)	248
No difficulties discussing HPV vaccination with close people	1134 (45)	873	1472 (59)	247
No difficulties discussing HPV vaccination with HCP	1069 (43)	874	1444 (58)	249
I'm not too young for HPV vaccination	1257 (50)	873	1756 (70)	247
Personally, benefits outweigh risks of HPV vaccination	1008 (40)	873	1472 (59)	248
Others getting vaccinated encourages me to do so	820 (33)	872	1121 (45)	247
Discussed HPV vaccination with friends	880 (35)	893	1407 (57)	269
Researched information on HPV vaccine risks/benefits	209 (8)	895	436 (18)	270
Helping to eliminate HPV through vaccination	916 (37)	894	1420 (57)	270
The school system meets my needs	1223 (44)	1	1270 (46)	1

Unfavorable responses included indecisive response options (i.e., “I don’t know”); the denominator for all percentages is the number of non-missing responses for the respective item.

Most questionnaire items used skip logic to only include participants who met at least one of the following criteria: 1) recalled speaking to their physician about either HPV in general or 2) the HPV vaccine; 3) recalled having been offered the HPV vaccine by a doctor; 4) recalled having heard of the HPV vaccine before, or 5) expressed uncertainty (but did not say no) to having heard of the HPV vaccine. At baseline, 865 respondents met these criteria and were systematically excluded from responding to most other questionnaire items. At follow-up, this number was reduced to 239 participants. Therefore, for those that are missing ≥865 responses at baseline, 865 of these responses are missing by design. Likewise, among questionnaire items that are missing ≥239 responses at follow-up, 239 of these responses are missing by design.

likely at follow-up to agree that the benefits of HPV vaccination outweighed the risk for them (OR = 1.6 [95 %-CI: 1.2, 2.0]), that it was important to not transmit HPV to others (1.5 [1.1, 2.1]), that they could easily discuss HPV with their doctor (1.4 [1.1, 1.8]), and that others getting vaccinated encouraged them to do so (1.4 [1.0, 1.8]). Discussing HPV vaccination with friends (1.8 [1.2, 2.6]) and knowing that friends were vaccinated (1.6 [1.2, 2.1]) were the two practice-related items with a significant positive effect from the in-school education and motivation component (Fig. 2).

Further adjusting for baseline KAP levels and receipt of other intervention components, participants in schools with free, in-school HPV vaccination were more likely to report knowing that their friends were vaccinated (3.1 [2.2, 4.2]), to have heard of the HPV vaccine before (2.2 [1.1, 4.3]), and to agree that the HPV vaccine was easy to access (2.2 [1.5, 3.2]), when compared to participants in schools without such campaigns (Fig. 3).

Adolescents whose municipalities were randomized to include the GP training component had a slightly higher likelihood at follow-up of finding it easy to access clear information about the HPV vaccine (1.3 [1.1, 1.6]), compared to adolescents in other municipalities (Fig. 4). However, they were more likely to report difficulties in discussing the vaccine with their family and friends (OR for finding easy, 0.76 [0.61,

0.96]).

In analyses stratifying the effect of the in-school education and motivation component by in-home multilingualism, we observed a differential effect on the perceived accessibility of clear information on HPV vaccination. Among all participants across study arms, 36 % at baseline and 57 % at follow-up agreed that it was easy to find clear information about the vaccine (Table 2). This percentage was 59 % among all participants receiving the in-school education component, and 52 % vs 60 % among multilingual vs French monolingual students with this intervention component (data not shown). In regression analyses, this resulted in a negative effect among multilingual students (0.46 [0.22, 0.93]), versus no significant effect among monolingual students (1.2 [0.99, 1.4]; Fig. 5).

#### 4. Discussion

In this cluster-randomized trial including a sample of adolescents in France aged 13–15 years, we found that in-school HPV education and motivation produced the greatest improvement in KAP items, notably among knowledge items and positive perceptions of the benefit-risk balance. By contrast, free, in-school HPV vaccination had a positive effect specifically on perceptions around vaccine accessibility and

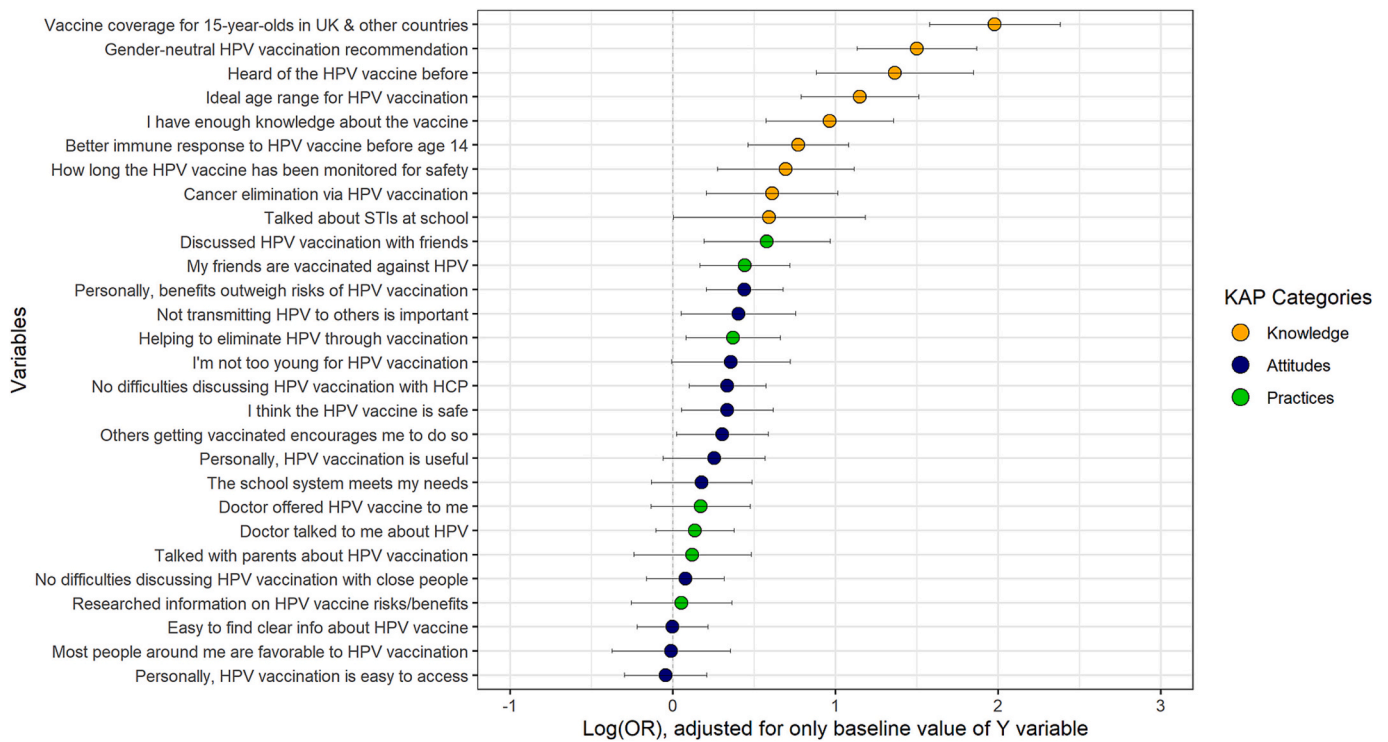


Fig. 2. – Effects of the in-school education and motivation component on individual questionnaire items.

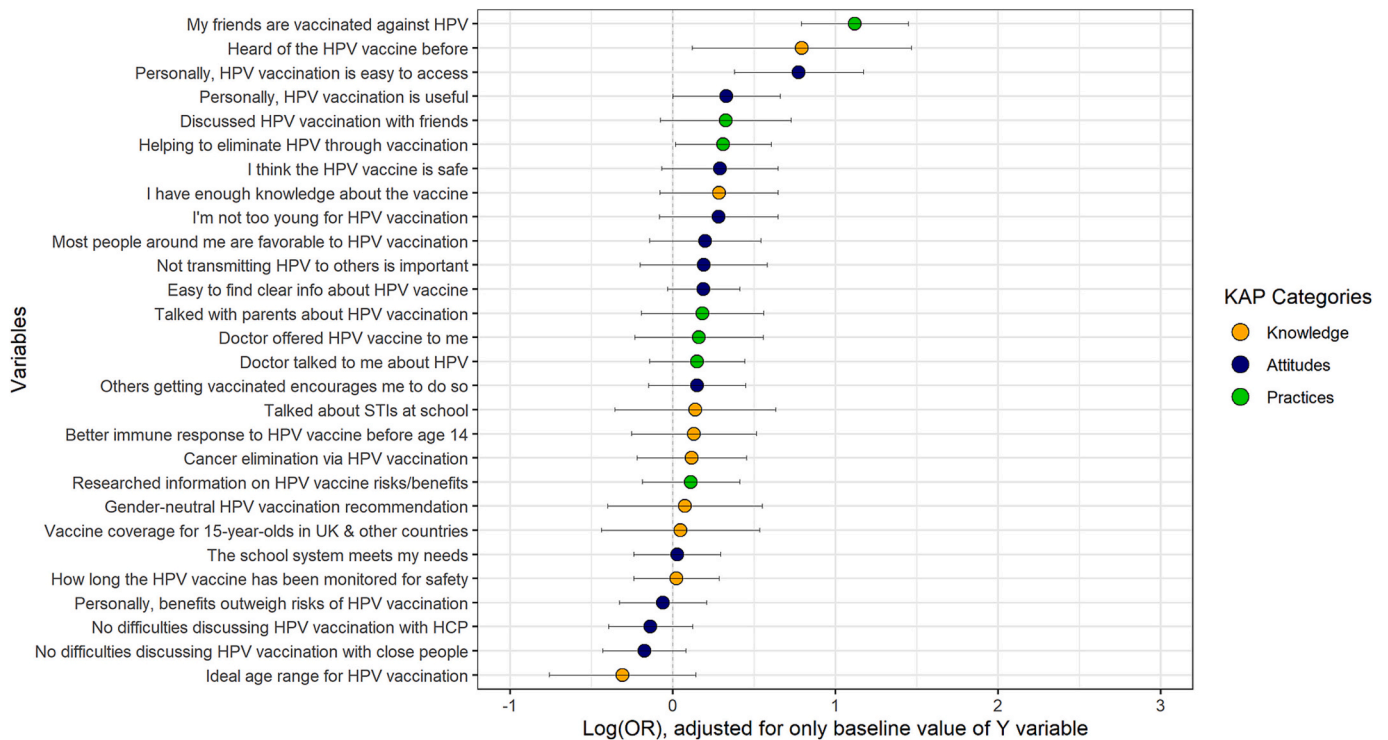


Fig. 3. – Effects of free in-school HPV vaccination on individual questionnaire items.

knowing friends who are vaccinated. Lastly, students whose municipalities were randomized to offer training to general practitioners saw a slight increase in their perceived ease of finding clear information and a slight increase in difficulty of discussing the vaccination with close persons compared to adolescents who were in municipalities that were not randomized to receive GP trainings.

While it is generally unsurprising that school-based education increases knowledge among students, the present study demonstrates that this specific in-school education and motivation component also improved vaccine literacy and influenced attitudes. Given the high levels of vaccine hesitancy in France [27–29], our study findings are particularly noteworthy as they suggest that school-based education can

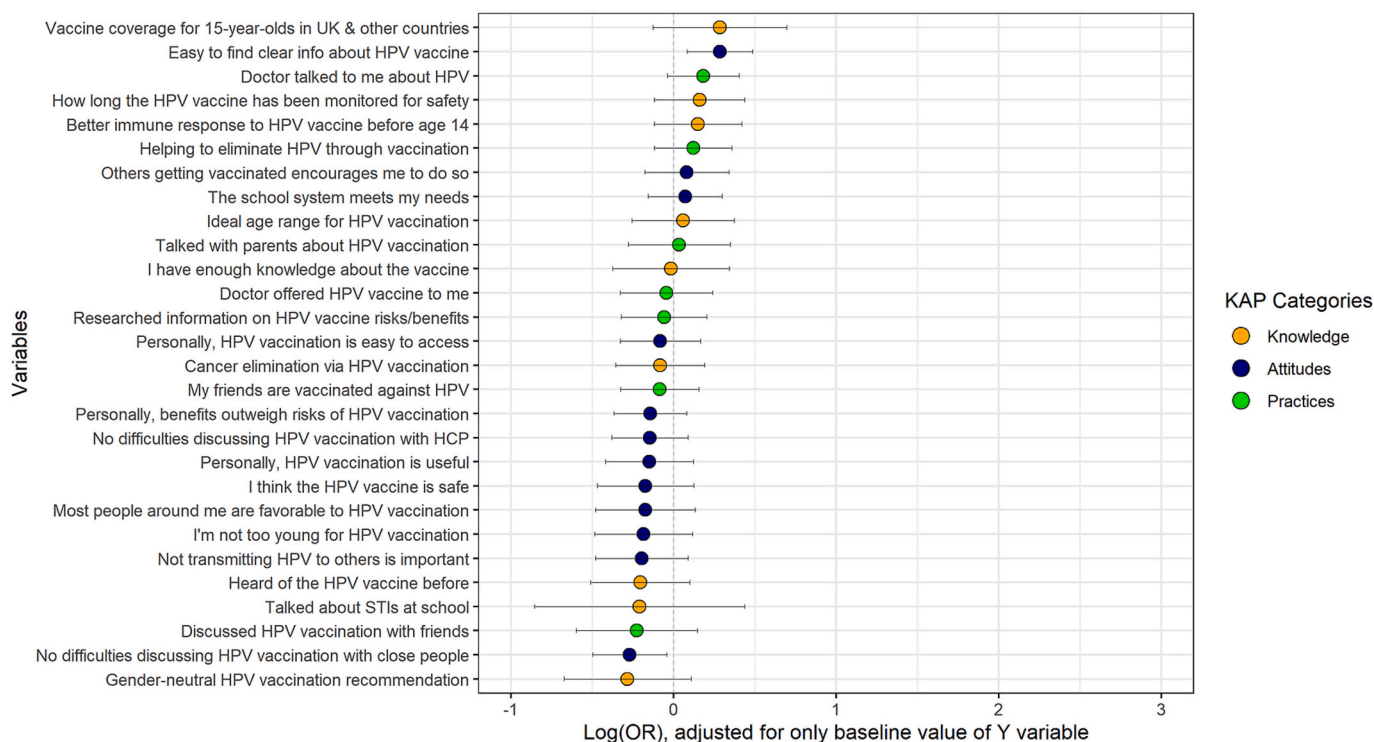


Fig. 4. – Effects of GP training on individual questionnaire items.

improve adolescents’ understanding of the safety and effectiveness of the HPV vaccine, influencing them toward more positive attitudes. Moreover, while decades of research have established that there is often a substantial gap between acquiring knowledge and behavioral change [30,31], more recent studies have shown that one’s assessment of the benefits of a given vaccine has been found to strongly determine intention to vaccinate and vaccine uptake [23,32]. Thus, in improving adolescents’ understanding of the safety, effectiveness, and other benefits of the HPV vaccine via the in-school education and motivation component, there may be downstream effects on eventual vaccine uptake.

Our study results demonstrate that free, in-school vaccination effectively increased the ease of access to the HPV vaccine and students’ awareness of their friends’ vaccine status. Moreover, the decomposed effects of in-school vaccination did not suggest that this component alone would influence knowledge and attitudes, even if they do elicit the target behavior (i.e., vaccination) among a percentage of individuals to whom free vaccination is offered. Indeed, published intention-to-treat results from the PrevHPV trial showed that free in-school HPV vaccination increased vaccine coverage (measured 2 months post-intervention) by an average 5 percentage points in municipalities randomized to receive this component [21]. By contrast, the education and motivation component did not increase vaccination uptake within the 5-month follow-up [21]. In the present study, we also found that students whose schools were randomized to offer free vaccination were more likely to know that their friends were vaccinated, a social component that in other studies has been associated with one’s own willingness to vaccinate [33–36]. In the context of previous trial results, our current results highlight the benefits of a joint intervention comprising in-school education and in-school vaccination components, as each component addresses distinct barriers to HPV vaccination (e.g., ignorance, hesitancy, inaccessibility). A conjoint application of these two components would be complimentary and without redundancy.

Our study did not find much impact of GP training on adolescents’ KAP. We did see that students in municipalities where GPs received training were slightly more likely to report that they could find clear

information on the HPV vaccine. While this was a small effect, it was consistent with the anticipated benefit of the GP training component, as GPs were offered a decision aid tool and training in motivational interviewing. Other results may be difficult to interpret given the short amount of time between the end of the intervention and follow-up questionnaire, which would not have allowed many adolescents the opportunity to see their regular GP. Moreover, few GPs participated within the municipalities assigned to this component [21], and we could not identify which students in our sample were patients of trained versus untrained GPs. It is for these reasons that we interpret results from this component with caution, and we also suggest that future studies in France could better examine the relationship between GP trainings and adolescents’ KAP by examining KAP among adolescents who were known to have visited a trained GP. Moreover, as parents play a key role in vaccine decision-making for their children and are present for their medical appointments, future studies would do well to also analyze parents’ KAP following GP trainings.

Finally, the results from our post-hoc analysis suggest that there were differences in the effect of in-school education and motivation on students’ KAP responses based on whether they spoke a language other than French at home. This analysis was motivated by the previously reported observation that free vaccine campaigns in schools were effective on the combined outcome “vaccine uptake or intention” irrespective of multilingualism, but that in-school education and motivation was effective only among French monolingual adolescents [24]. We here observed that multilingual students were more likely to report difficulty in accessing clear information on HPV vaccination at follow-up compared to their monolingual counterparts. Of note, this subgroup analysis was limited by a small sample of multilingual students, and the distribution of these students was unequal across randomization arms, likely due to the non-participation of 31 middle schools that were originally randomized. This calls into the question of exchangeability of these multilingual participants across randomization arms [37]. Language barriers certainly exist for multilingual families; however, in France, many multilingual families have origins in countries where French is taught at school (eg, in Northern and Western Africa, in French

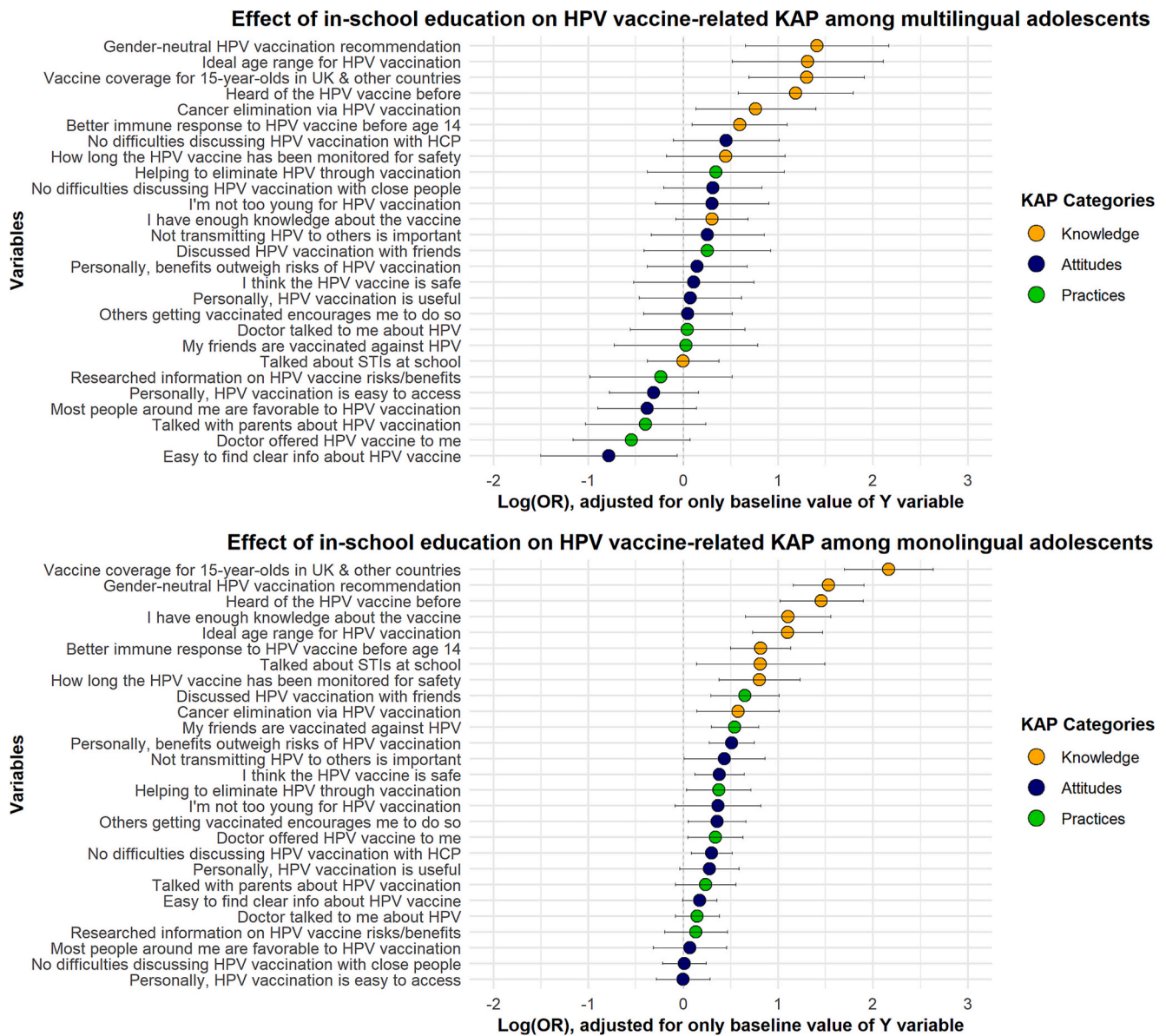


Fig. 5. – Post-hoc analysis of the modification of the effect of the in-school education and motivation component by at-home multilingualism.

Oversees departments). For adolescents, the fact that improvements in knowledge items were not substantially lower in multilingual than monolingual students suggests that language barriers were not at play in the lower gain in intention. We hypothesize that parents in families originating outside mainland France are differently exposed to negative communication and believes on HPV vaccination in their social environment, and that adolescents experienced difficulties in convincing their parents about HPV vaccination. These findings suggest that additional tailoring of educational materials is required. For this, we recommend qualitative work to better understand the linguistic, educational, cultural and programmatic barriers around vaccine promotion in France. Such barriers may relate not only to understanding HPV vaccine information, but also to framing it within other beliefs and messages received in the social environment.

The present study had several limitations. First, there were eligible adolescents whose data were not captured in this cohort, either due to not having completed one of the two questionnaires, or because their ID was not correctly entered in one of the questionnaires, making it impossible to link the two. Among the 13,233 adolescents at the remaining 60 participating middle schools, only 20 % completed the

KAP questionnaire at baseline and follow-up while correctly entering their unique ID. Such a large loss in sample size could induce selection bias if the current sample does not represent a simple random sample of the original sample (i.e., if data missingness is contingent on the value of a variable related to our analyses) [38,39]. While restricting to only baseline questionnaires would not circumnavigate this issue (as many eligible adolescents did not complete baseline questionnaires), our assessment of differences in the full baseline data available compared to those retained for the linkable follow-up cohort suggests that participants in the linkable follow-up cohort have a similar distribution of sociodemographic characteristics compared to the full baseline data available, with an important exception for multilingualism.

A second limitation is that the analyses assumed that all exposures were homogenous across middle schools based on being randomized to the same intervention components. In other words, the analysis assumed that all adolescents in our cohort received the same educational materials and the same amount of class time discussing HPV and vaccination. Further, it assumed that all in-school vaccination occurred uniformly across all schools randomized, and that all adolescents living in municipalities that were randomized to receive GP training had equal

opportunity to receive services from a trained GP. If these assumptions are not valid, as already explored in the case of the GP training component, there is a risk that our results are biased. However, if many adolescents did not receive the anticipated intervention dose, we would expect our results presented here to be less extreme than the underlying truth.

Lastly, due to the anonymous nature of the survey, we did not collect data on which classroom each student attended or which GP they visited. However, there may have been meaningful clustering among adolescents who were taught by the same teacher or offered the vaccine by the same healthcare professional. Such clustering was unmeasured and therefore unaccounted in our statistical analysis approach, which only assumes school-level clustering of observations and clustering on a more granular level.

Our study also had several strengths. First, the factorial design of this study offered the opportunity to study three intervention components in different combinations; this also allowed us to statistically approximate the unique benefits that each intervention component offered to adolescents. Additionally, the study questionnaire offered a wide variety of knowledge, attitude, and practice items, giving us a more granular level of detail about what beliefs and behaviors were altered because of the study intervention components.

## 5. Conclusion

Taken together, our results suggest that joint in-school HPV education and vaccination campaigns could function well together to improve immediate and future vaccine uptake. In-school education and motivation increase students' HPV vaccine-related knowledge, improve their perception of the vaccine's safety and effectiveness, and have the potential to motivate them toward having more vaccine-favorable beliefs and engaging in vaccine-favorable behaviors. Meanwhile, free in-school HPV vaccination significantly increases the ease of access to HPV vaccination for students who are motivated to get vaccinated. In 2023, France has introduced a policy for school-based HPV vaccination campaigns targeting middle school students in 5<sup>ème</sup> (equivalent to US grade 7 or UK year 8; students aged approximately 11–12 years). Considering our study results, we recommend that these campaigns be systematically combined with in-school education and motivation programs with the goal to maximize immediate effectiveness and long-term impact on vaccine acceptance. Furthermore, as parental consent is required for vaccination in France, such education and motivation material should also be tailored to meet the needs of families from a variety of linguistic and cultural backgrounds to increase accessibility and acceptability of HPV vaccine promotion. When vaccine campaigns and appropriate in-school education are offered in unison over the course of multiple academic years, we would expect to achieve higher vaccine coverage and see adolescents and their families become more amenable to vaccination in general.

### Availability of data and materials

The data that support the findings of this study are not publicly available. They are, however, available upon reasonable request and with permission of the French National Institute for Health and Medical Research (Inserm). The reuse of data is subject to compliance with the General Data Protection Regulation (GDPR) and French regulations.

### CRedit authorship contribution statement

**Josée M. Dussault:** Writing – original draft, Methodology, Formal analysis. **Alexia F. Rivera Torres:** Writing – review & editing, Visualization, Formal analysis. **Damien Oudin Doglioni:** Writing – review & editing, Investigation, Data curation, Conceptualization. **Amandine Gagneux-Brunon:** Writing – review & editing, Investigation, Funding acquisition, Data curation, Conceptualization. **Anne-Sophie Le Duc-**

**Banaszuk:** Writing – review & editing, Investigation, Funding acquisition, Data curation, Conceptualization. **Sébastien Bruel:** Writing – review & editing, Investigation, Funding acquisition, Data curation, Conceptualization. **Morgane Michel:** Methodology, Investigation, Conceptualization. **Aurélié Gauchet:** Writing – review & editing, Investigation, Funding acquisition. **Anne-Sophie Barret:** Writing – review & editing, Conceptualization. **Jonathan Sicsic:** Writing – review & editing, Methodology, Conceptualization. **Jocelyn Raude:** Writing – review & editing, Methodology, Conceptualization. **Nathalie Thilly:** Writing – review & editing, Supervision, Investigation, Funding acquisition, Conceptualization. **Judith E. Mueller:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

### Ethics approval and consent to participate

The French Ethics Committee “CPP Sud-Est VI” approved the study protocol on December 22, 2020 (ID-RCB: 2020-A02031–38). It was then submitted to [ClinicalTrials.gov](https://www.clinicaltrials.gov) for registration (NCT04945655). Individual consent was not required for this type of survey, according to the French law. Nevertheless, all participants were informed of their right to decline participation or to oppose to the collection of data.

### Funding

The study is conducted with the support of IReSP and with financial support from ITMO Cancer AVIESAN (Alliance Nationale pour les Sciences de la Vie et de la Santé/ National Alliance for Life Sciences & Health) within the framework of the Cancer Plan 2014–2019. Author JMD received a postdoctoral training fellowship funded by the Gillings Foundation. The ITMO Cancer AVIESAN and the Gillings Foundation had no role in the design of the study and in writing the manuscript; it will have no role in the collection, analysis, and interpretation of data.

For the purpose of open access, the author has applied CC-BY copyright licence to any Author Manuscript version arising from this submission.

### Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Judith Mueller reports financial support was provided by ITMO Cancer AVIESAN. Josée Dussault reports financial support was provided by Gillings Foundation. Amandine Gagneux-Brunon reports a relationship with MSD France SAS that includes: speaking and lecture fees. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Acknowledgements

The authors thank members of the National Education for the collaboration in this study, in particular the direction générale de l'enseignement scolaire (DGESCO) and participating schools.

The PrevHPV Study group includes, beyond the authors of the present manuscript, for team 1: Aurélié Bocquier, Maïa Simon; for team 2: Marie Ecollan, Serge Gilberg, Dragos-Paul Hagi, Josselin Le Bel, Henri Partouche, Juliette Pinot, Louise Rossignol, Arthur Tron; for the team 3: Julien Ailloud, Julie Bros, Olivier Epaulard, Catherine Juneau, Gaëlle Vareilles; for team 5: Elisabeth Botelho-Nevers, Emily Darlington, Géraldine Jambon, Julie Kalecinski, Mabrouk Nekaa; for team 7: Anne-Sophie Barret, Isabelle Bonmarin, Daniel Levy-Bruhl, Jocelyn Raude, Jonathan Sicsic; for team 8: Bruno Giraudeau; Clémence Castagnet (Inserm/PRC) and Mélanie Simony (IReSP).

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2025.127344>.

## Data availability

Data will be made available on request.

## References

- [1] World Health Organization. Weekly Epidemiological Record, 2022, vol. 97, 50. *Wkly Epidemiol Rec Relevé Épidémiologique Hebdo* 97(50); 2022. p. 645–72.
- [2] National Institute of Cancer. HPV and Cancer [internet]. Bethesda, MD: National Cancer Institute; 2023. Available from: <https://www.cancer.gov/about-cancer/causes-prevention/risk/infectious-agents/hpv-fact-sheet>.
- [3] De Sanjose S, Quint WGV, Alemany L, Geraets DT, Klaustermeier JE, Lloveras B, et al. Human papillomavirus genotype attribution in invasive cervical cancer: a retrospective cross-sectional worldwide study. *Lancet Oncol* 2010;11(11):1048–56.
- [4] Faraji F, Rettig EM, Tsai HL, El Asmar M, Fung N, Eisele DW, et al. The prevalence of human papillomavirus in oropharyngeal cancer is increasing regardless of sex or race, and the influence of sex and race on survival is modified by human papillomavirus tumor status. *Cancer* 2019;125(5):761–9.
- [5] Medeiros LR, Rosa DD, Da Rosa MI, Bozzetti MC, Zanini RR. Efficacy of human papillomavirus vaccines: a systematic quantitative review. *Int J Gynecol Cancer* 2009;19(7).
- [6] Kjaer SK, Sigurdsson K, Iversen OE, Hernandez-Avila M, Wheeler CM, Perez G, et al. A pooled analysis of continued prophylactic efficacy of quadrivalent human papillomavirus (types 6/11/16/18) vaccine against high-grade cervical and external genital lesions. *Cancer Prev Res (Phila)* 2009;2(10):868–78.
- [7] Ministère de la Santé et de la Prévention. Calendrier Des Vaccinations Et Recommandations Vaccinales 2023 [Internet]. Available from: <https://pratiquesnsante.odoo.com/blog/outils-6/calendrier-des-vaccinations-et-recommandations-vaccinales-2023-2281>; 2023. Last accessed March 31, 2025.
- [8] Haute Autorité de Santé. Synthèse de la Recommandation Vaccinale: Vaccination Contre les Papillomavirus chez les Garçons [Internet]. Available from, [https://www.mesvaccins.net/textes/fiche\\_synthese\\_recommandation\\_vaccinale\\_vaccination\\_papillomavirus\\_garcons.pdf](https://www.mesvaccins.net/textes/fiche_synthese_recommandation_vaccinale_vaccination_papillomavirus_garcons.pdf); 2019.
- [9] French National Academy of Medicine. Vaccination Against the Human Papillomavirus (HPV): France Is Far Behind Other Countries [Internet]. Available from, <https://www.academie-medecine.fr/vaccination-against-the-human-papillomavirus-hpv-france-is-far-behind-other-countries/?lang=en>; 2022.
- [10] World Health Organization (WHO). Human Papillomavirus (HPV) Vaccination Coverage [Internet]. Available from, <https://immunizationdata.who.int/pages/coverage/hpv.html>; Last accessed March 31, 2025.
- [11] French Institute of Cancer (INCa). [Decennial strategy of cancer control 2021–2030. Road map 2021–2025.] [Internet]. Page 15. Available from: [https://sante.gouv.fr/IMG/pdf/feuille\\_de\\_route\\_-\\_strategie\\_decennale\\_de\\_lutte\\_contre\\_les\\_cancer\\_s.pdf](https://sante.gouv.fr/IMG/pdf/feuille_de_route_-_strategie_decennale_de_lutte_contre_les_cancer_s.pdf). Last accessed May 28, 2025.
- [12] Institut National du Cancer. Stratégie décennale de lutte contre les cancers 2021–2030 - feuille de route 2021–2025. 2021.
- [13] Karafillakis E, Peretti-Watel P, Verger P, Chantler T, Larson H. The role of maturity in adolescent decision-making around HPV vaccination in France. *Vaccine* 2021;39(40):5741–7.
- [14] Karafillakis E, Peretti-Watel P, Verger P, Chantler T, Larson HJ. “I trust them because my mum trusts them”: exploring the role of trust in HPV vaccination decision-making among adolescent girls and their mothers in France. *Vaccine* 2022;40(8):1090–7.
- [15] Mullins TL, Griffioen AMM, Glynn S, Zimet GD, Rosenthal SL, Fortenberry JD, et al. Human papillomavirus vaccine communication: perspectives of 11–12 year-old girls, mothers, and clinicians. *Vaccine* 2013;31(42):4894–901.
- [16] Herman R, McNutt LA, Mehta M, Salmon DA, Bednarczyk RA, Shaw J. Vaccination perspectives among adolescents and their desired role in the decision-making process. *Hum Vaccin Immunother* 2019;15(7–8):1752–9.
- [17] Kwan TT, Tam KF, Lee PW, Chan KK, Ngan HY. The effect of school-based cervical cancer education on perceptions towards human papillomavirus vaccination among Hong Kong Chinese adolescent girls. *Patient Educ Couns* 2011;84(1):118–22.
- [18] World Health Organization. Adolescent Health and Development [Internet]. Available from, <https://www.who.int/news-room/questions-and-answers/item/adolescent-health-and-development>; 2025.
- [19] Goodwin NP, Mrug S, Borch C, Cillessen AH. Peer selection and socialization in adolescent depression: the role of school transitions. *J Youth Adolesc* 2012;41:320–32.
- [20] Bocquier A, Michel M, Giraudeau B, Bonnay S, Gagneux-Brunon A, Gauchet A, et al. Impact of a school-based and primary care-based multicomponent intervention on HPV vaccination coverage among French adolescents: a cluster randomised controlled trial protocol (the PrevHPV study). *BMJ Open* [Internet] 2022;12(3). Available from: <https://bmjopen.bmj.com/content/bmjopen/12/3/e057943.full.pdf>.
- [21] Thilly N, Michel M, Simon M, Bocquier A, Gagneux-Brunon A, Gauchet A, et al. Effectiveness of a School- and Primary Care-Based HPV Vaccination Intervention: The PrevHPV Cluster Randomized Trial. *JAMA Netw Open* 2024;7(5):e2411938.
- [22] Moirangthem S, Olivier C, Gagneux-Brunon A, Péllissier G, Abiteboul D, Bonmarin I, et al. Social conformism and confidence in systems as additional psychological antecedents of vaccination: A survey to explain intention for COVID-19 vaccination among healthcare and welfare sector workers, France, December 2020 to February 2021. *Eurosurveillance* [Internet]. 2022 [cited 2023 Mar 3];27(17). Available from: <https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2022.27.17.2100617>.
- [23] Oudin Doglioni D, Gagneux-Brunon A, Gauchet A, Bruel S, Olivier C, Pellissier G, et al. Psychometric validation of a 7C-model of antecedents of vaccine acceptance among healthcare workers, parents and adolescents in France. *Sci Rep* 2023;13(1):19895.
- [24] Dussault J, Le Duc-Banaszuk AS, Gagneux-Brunon A, Bruel S, Gauchet A, Barret AS, et al. Effect of school-based HPV vaccine campaigns on inequalities in uptake in France, the PrevHPV trial. *Eur J Public Health*. 2023 Oct 24;33(Suppl 2). [ckad160.398](https://doi.org/10.1093/eurpub/ckad160.398).
- [25] StataCorp. Stata statistical software: Release 17. College Station, TX: StataCorp LLC; 2021.
- [26] Wickham H. *Ggplot2: Elegant graphics for data analysis*. 2nd ed. Cham, Switzerland: Springer International Publishing; 2016 [Use R!].
- [27] Fokoun C. Strategies implemented to address vaccine hesitancy in France: a review article. *Hum Vaccin Immunother* 2018;14(7):1580–90.
- [28] Rey D, Fressard L, Cortaredona S, Bocquier A, Gautier A, Peretti-Watel P, et al. Vaccine hesitancy in the French population in 2016, and its association with vaccine uptake and perceived vaccine risk–benefit balance. *Eurosurveillance* 2018; 23(17):17.
- [29] Schwarzingler M, Watson V, Arwidson P, Alla F, Luchini S. COVID-19 vaccine hesitancy in a representative working-age population in France: a survey experiment based on vaccine characteristics. *Lancet Public Health* 2021;6(4):e210–21.
- [30] Finger M. From knowledge to action? Exploring the relationships between environmental experiences, learning, and behavior. *J Soc Issues* 1994;50(3):141–60.
- [31] Kennedy T, Regehr G, Rosenfield J, Roberts SW, Lingard L. Exploring the gap between knowledge and behavior: a qualitative study of clinician action following an educational intervention. *Acad Med* 2004;79(5):386.
- [32] Lièvre G, Sicsic J, Galmiche S, Charmet T, Fontanet A, Mueller JE. Are the 7C psychological antecedents associated with COVID-19 vaccine behaviours beyond intentions? A cross-sectional study on at-least-one-dose and up-to-date vaccination status, and uptake speed among adults in France. *Vaccine* 2024;42(14):3288–99.
- [33] Shin MB, Sloan KE, Martinez B, Soto C, Baezconde-Garbanati L, Unger JB, et al. Examining multilevel influences on parental HPV vaccine hesitancy among multiethnic communities in Los Angeles: a qualitative analysis. *BMC Public Health* 2023;23(1):545.
- [34] Grandahl M, Nevéus T, Dalianis T, Larsson M, Tydén T, Stenhammar C. ‘I also want to be vaccinated!’ – adolescent boys’ awareness and thoughts, perceived benefits, information sources, and intention to be vaccinated against human papillomavirus (HPV). *Hum Vaccin Immunother* 2018;15(7–8):1794–802.
- [35] Fernandes R, Potter BK, Little J. Attitudes of undergraduate university women towards HPV vaccination: a cross-sectional study in Ottawa, Canada. *BMC Womens Health* 2018;18(1):134.
- [36] Yagi A, Ueda Y, Tomine Y, Ikeda S, Kakuda M, Nakagawa S, et al. The ‘best friend effect’: a promising tool to encourage HPV vaccination in Japan. *Int J Clin Oncol* 2022;27(11):1750–7.
- [37] Webster-Clark M, Baron JA, Jonsson Funk M, Westreich D. How subgroup analyses can miss the trees for the forest plots: a simulation study. *J Clin Epidemiol* 2020; 126:65–70.
- [38] Westreich D. Berkson’s bias, selection bias, and missing data. *Epidemiol Camb Mass* 2012;23(1):159–64.
- [39] Ross RK, Breskin A, Westreich D. When is a complete-case approach to missing data valid? The importance of effect-measure modification. *Am J Epidemiol* 2020;189(12):1583–9.